ELECTROMAGNETIC FIELD OF A DIPOLE SOURCE ABOVE A GROUNDED DIELECTRIC SLAB

BY

YUEN TZE LO

B.E., National Southwest Associated University, China, 1942
M.S., University of Illinois, 1949

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1952

URBANA, ILLINOIS

1952

ELECTROMAGNETIC FIELD OF A DIPOLE SOURCE ABOVE A GROUNDED DIELECTRIC SLAB

BY

YUEN TZE LO

B.E., National Southwest Associated University, China, 1942
M.S., University of Illinois, 1949

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1952

URBANA, ILLINOIS

1952

ACKNOWLEDGEMENT

This Thesis has been prepared under the supervision of Professor E. C. Jordan of the Department of Electrical Engineering, University of Illinois. The author wishes to express his deep gratitude to him for his able guidance. He is especially indebted to Dr. C. T. Tai for his suggestions on this problem and also many valuable discussions. The author is also indebted to Professor E. J. Scott for reviewing the manuscript.

R. UNIV. BIBLIOTHEEK LEIDEN

ELECTROMAGNETIC FIELD OF A DIPOLE SOURCE ABOVE A GROUNDED DIELECTRIC SLAB

In this thesis, an attempt has been made to investigate the electromagnetic fields of a dipole source above a grounded dielectric slab. The method of fourier transforms has been used to obtain the solutions in integral form which are then evaluated asymptotically in a complex plane by the saddle-point method of integration for the distant fields.

In the first part of the thesis, a vertical dipole source is considered. The potential field is found to be a sum of the space wave and the residue wave. The former, spherical in nature, is identified as the radiation field. The latter, resulted from the pole of the integrand in the complex plane and cylindrical in nature, is identified as the Zenneck surface wave. Due to the fact that it is found there is at least a pole for any finite thickness of the slab, the surface wave always exists. However, its magnitute will be of greater significance if the thickness differs slightly from the critical values and the dipole is near the interface.

The residue wave in the dielectric slab is a TM-wave guided between its two boundary surfaces and propagating in the ρ-direction. For finite thickness of the slab there is a finite number of modes, but only the mode due to the pole closest to $\pi/2$ is dominant.

Along the interface, the space wave will be zero for non-critical thickness. For critical thickness the space wave will be twice as large as the field due to the dipole in free space. The solution for the thickness near the critical value is found to be a function of the product of the distance of the point of observation and the square of the vectorial difference between the pole and the saddle-point. This is quite similar to that of Sommerfeld's problem concerning wave propagation over a highly conducting earth. As the thickness becomes very close the critical value, the pole approaches the saddle-point and

there results a surface wave term again.

Since the space wave at the interface is zero for non-critical thickness, a higher order solution, which represents the induction field, has been obtained.

In the second part of the thesis, a horizontal dipole source is considered. The solutions are very similar to those in the first part, except a vertical component of the potential field exists in addition to the expected horizontal component. The former can be considered as excited by the latter as a result of the inhomogeneity of the medium. The reflection coefficient of the horizontal component has exactly the same expression as that of a two dimensional version of this prorblem investigated by Tai. On the other hand, the vertical component has mixed properties of this horizontal component and the field due to a vertical dipole.

The radiation pattern of the space wave of the potential field due to a vertical dipole has been prepared in simple cases for the study of the radiation effect of the dielectric slab upon the dipole.

VITA

The author, Yuen Tze Lo, was born on January 31, 1920 in Hankow, China. He graduated from the National Southwest Associated University of China with a B. E. degree in electrical engineering in 1942. After that he joined the Radio Research Institute, National Tsing Hua University of China, where he worked for four years. From 1946 to 1948, he was an instructor in the Department of Electrical Engineering, National Tsing Hua University. Since 1948, he has been in attendance at the University of Illinois where he received the degree of M. S. in June, 1949.

He has held a University Fellowship from 1949 until the present.

He is a member of the Institute of Raido Engineers, and the Phi Kappa Phi.